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Distinct physiological characteristics of two subspecies of *Aster tripolium* L.

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Aster tripolium L. (Asteraceae/Compositae) is a typical halophyte species with two horizontally isolated subspecies, *i.e.* ssp. tripolium and ssp. pannonicus (Borhidi 1995). The two subspecies are very different concerning their habitats, morphology and physiology. The ssp. tripolium, or sea aster, is a maritime halophyte and is widespread along the Atlantic coasts, while ssp. pannonicus is common on the continental salty meadows, a typical species of the Hungarian alkaline *puszta* (steppe) vegetation. Morphological differences are obvious in leaf size and shape, leaf color, leaf number and growth habitus. Both ssp. accumulate inorganic ions even at low external concentrations. Physiologically sea aster was more intensively studied (Shennan et al. 1987ab) because of its recently increasing commercial importance as halophyte crop. Its value is the mild salty taste and high protein content of the succulent leaves. The ssp. pannonicus inhabits salty meadows rich in $NaHCO_3$ thus having high pH. The aim of the present work is to compare the two subspecies for their growth and mineral accumulation as well as changes in protein composition as the function of pH and Na^+ concentration.

Materials and Methods

Plants were grown hydroponically in containers filled with 7 L complete nutrient solution of different pH values (from 4 to 10). In one container, 7 plants of each of the subspecies were placed and were grown for 6 weeks under controlled conditions in greenhouse at an additional light intensity of 100 μmol m^{-2} s^{-1} for 12 hours. Day/night temperature was 24/18ºC. The pH values were controlled and adjusted daily by addition of HCl or NaOH. The nutrient solution was exchanged weekly. The biomass of the plant individuals was weighed weekly, and root length as well as leaf number were determined. At the end of the 6th week, protein (Bradford 1976) and chlorophyll content, fresh and dry mass were measured.

On the basis of growth data 2 pH values, pH 5 and 8, were selected and a new series of plants were grown at 0, 50, 100, 200 and 300 mM NaCl concentrations added to the complete nutrient solution. During the 7 weeks of the experiment all the control measures mentioned above were taken. At the 7th week plants were sampled as mentioned and protein composition was determined by gel electrophoresis. Cation concentrations were determined by atomic absorption spectrophotometry (Hitachi, Type Z-8200).

SDS-polyacrylamide gel electrophoresis (SDS-PAGE). Low molecular mass (1-100 kD) proteins were separated using Mini-Protean II Dual Slab (Bio-Rad) vertical cell and EPS 500/400 (Pharmacia LKB) power supply.

Results and Discussion

Different growth responses were given by the two subspecies both under salt and pH stresses. Due to the succulent morphology, the relative growth rate and fresh weight to dry weight ratio was higher in *A. t.* ssp. tripolium than in ssp pannonicus. Because of the lack of succulence, ssp. pannonicus showed low water content especially under high salt concentrations. In the function of pH, ssp. pannonicus had a growth optimum at pH 8 which is in accordance with the pH conditions of its natural biotop, the alkaline *puszta* meadow.

Higher pigment (chlorophyll and carotenoids) concentrations were found in ssp pannonicus than in ssp tripolium at all pH values and each salt concentrations. Ssp. tripolium obviously suffered under low salt conditions combined with high pH values as shown by the low pigment concentrations.

In both subspecies, qualitative and quantitative alterations were observed in protein concentrations with increasing salinity and pH values. At low pH and medium salt concentrations, ssp tripolium had higher protein levels than ssp pannonicus while at high pH values ssp. pannonicus had higher performance. For qualitative changes, SDS gel electrophoresis revealed a 50 kDa molecular mass protein which was induced by salinity in ssp pannonicus while a 70 kDa protein was found in higher quantities in the leaves of ssp. tripolium. The appearance of a 60 kDa protein was most abundant in plants grown at pH 5 compared to that in plants at pH 8 (Fig. 1).

For the ion uptake mechanisms it was observed that Na^+ accumulation showed double saturation kinetics at the higher pH region in both ssp and in the acid region in ssp. pannonicus. Very high Na^+ concentrations were accumulated in the leaves in both pH regions (4 mg Na^+ g^{-1} DW). Calcium is known to play a special role in tolerance under salinity. Surprisingly, in ssp. pannonicus Ca^{2+} accumulation increased under the highest NaCl concentrations (300 mM) while in contrast, ssp. tripolium showed a decreasing tendency in calcium accumulation under increasing external salinity.

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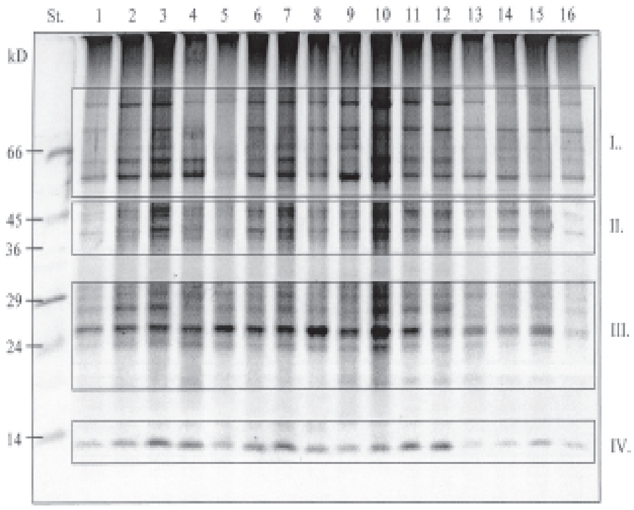

Figure 1. Comparison of protein patterns in the shoots of *Aster tripolium* ssp. tripolium and ssp. pannonicus by SDS PAGE gel electrophoresis.

Symbols:

St: standards for molecular mass

Lane	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
NaCl, mM	0	50	100	200	0	50	100	200	0	50	100	200	0	50	100	200
pH	5				8				5				8			
Species	*Aster tripolium* ssp. pannonicus								*Aster tipolium* ssp. tripolium							

Conclusion

In general, it can be concluded that *Aster tripolium* ssp. pannonicus is a subspecies which is adapted to extreme alkaline conditions (pH 8-11 in the natural habitat) and this is reflected in some of the growth parameters, high pigment and protein contents and ion accumulation mechanisms. Under high salinity, in both subspecies quantitative and qualitative changes appeared in their protein level and protein composition as adaptive response to the environmental conditions.

Acknowledgments

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